

Teacher Readiness and Strategy in the Implementation of Digital Pedagogy in 21st Century Education

Fadhilla Nangroe Anggraini^{1,*}, Muh. Nur Rochim Maksum², Mohammad Zakki Azani³,
Lutfi Azzahrowaini⁴, Fauzan Addinul Jihad⁵, Saminur Fauzan⁶

1 University of Muhammadiyah Surakarta, Surakarta, Indonesia

2 University of Muhammadiyah Surakarta, Surakarta, Indonesia

3 University of Muhammadiyah Surakarta, Surakarta, Indonesia

4 University of Muhammadiyah Surakarta, Surakarta, Indonesia

5 University of Muhammadiyah Surakarta, Surakarta, Indonesia

6 International Islamic University Malaysia, Malaysia

* Email: o100240030@student.ums.ac.id

ABSTRACT

The rapid development of digital technology has had a major impact on the world of education in the 21st century. This study aims to analyze the readiness and strategies of teachers in implementing digital pedagogy in Indonesia. Using a *narrative literature review* approach, this study synthesizes various research findings for the period 2020–2025 with a focus on three main aspects: technical competence, pedagogical adaptability, and institutional support. The TPACK and DigCompEdu frameworks are used as analytical tools in understanding teachers' digital competencies. The results show that although most teachers have basic digital literacy, there is still a significant gap in the ability to integrate technology effectively and contextually in the learning process. These challenges are exacerbated by inequality of access to infrastructure, lack of ongoing training, and lack of policy support, especially in 3T (frontier, outermost, disadvantaged) areas. The study also identifies a range of adaptive pedagogical strategies needed to address these challenges, such as digital security literacy, cross-platform integration, and locality-based training. The contribution of this research lies in a holistic approach that combines psychopedagogical and technological dimensions, as well as providing practical recommendations for education stakeholders in building an equitable, competitive, and sustainable digital learning ecosystem.

KEYWORDS: 21st century education; DigCompEdu; digital pedagogy; teacher readiness; TPACK

INTRODUCTION

The rapid development of digital technology has brought significant changes in various aspects of life, including the world of education. 21st century education demands the integration of technology in the learning process to create a learning experience that is more interactive, innovative, and relevant to the needs of the times (Hawinda Widya Fatma, M. Nur Fahmi, Darmawan, 2025). Teachers as the spearhead of education are required to have adequate readiness in adopting digital pedagogy in order to optimize the potential of technology in supporting the achievement of 21st century competencies, such as critical thinking skills, creativity, communication, and collaboration (P. Digital, 2024) (Fatma, H. W., Fahmi, M. N., 2025).

However, the reality on the ground shows that teachers' readiness to face digital transformation is still a major challenge. Based on the latest national survey, only about 45% of teachers in Indonesia feel technically and pedagogically ready to integrate digital technology in learning (L. Digital et al., 2025). This is due to various factors, including limited digital skills, lack of ongoing training, and suboptimal institutional support (P. Saltifa, O. Hidayah, 2025). In addition, the inequality of access to

technology between urban areas and remote areas also exacerbates the gap in teacher readiness (Hawinda Widya Fatma, M. Nur Fahmi, Darmawan, 2025).

A recent literature review reveals that teachers' readiness in digital pedagogy involves three main aspects: technical skills, pedagogical adaptability, and institutional support (Hawinda Widya Fatma, M. Nur Fahmi, Darmawan, 2025). Competency models such as TPACK (Technological Pedagogical Content Knowledge) and DigCompEdu are important frameworks in understanding and measuring digital teacher readiness (P. Digital, 2024) (Mishra, P., & Koehler, 2006a). Previous studies have highlighted many technical aspects and technological knowledge, but there is still a lack of comprehensive discussion of effective and contextual digital pedagogy implementation strategies in Indonesia (L. Digital et al., 2025) (Redecker, 2017). In addition, most of the research is conducted in developed countries, making it less relevant to the conditions of educational infrastructure and culture in developing countries such as Indonesia.

This research offers novelty by integrating the analysis of teacher readiness from the psychopedagogical and technological aspects while mapping the implementation strategy of digital pedagogy in accordance with the context of 21st century education in Indonesia (UNESCO, 2022). This approach is expected to make a theoretical and practical contribution in supporting an inclusive and sustainable digital education transformation (Wijaya, A. F., & Nurhasanah, 2024). In addition, this study also identifies gaps and challenges faced by teachers in the field and provides recommendations for strategies to strengthen teacher competencies that can be implemented by education stakeholders.

The main objective of this study is to analyze teacher readiness and strategies used in implementing digital pedagogy in 21st century education in Indonesia. This research also aims to provide a quantitative picture of the level of teacher readiness based on survey data and previous studies, as well as examine the factors that affect the effectiveness of the use of digital pedagogy in the learning process (L. Digital et al., 2025).

The urgency of writing this journal is very high considering that digital transformation in education is increasingly urgent, especially after the Covid-19 pandemic which has accelerated the adoption of online and hybrid learning (Hawinda Widya Fatma, M. Nur Fahmi, Darmawan, 2025) (Ramadhan, R., & Saputri, 2023). Education that is adaptive to technology is no longer an option, but a necessity to produce a generation that is able to compete globally and contribute to the development of the nation. By understanding teacher readiness and digital pedagogy implementation strategies, it is hoped that education policies and training programs can be designed more on target so that they can significantly and sustainably improve the quality of learning (P. Saltifa, O. Hidayah, 2025).

METHODOLOGY

This study uses the **Literature Review** as the main approach to analyze teacher readiness and digital pedagogy implementation strategies in 21st century education (Pratama, R. Y., & Suhendra, 2023). This method was chosen because it allows for the comprehensive searching, collection, and synthesis of various relevant research findings without conducting direct primary data collection.

Research Design

The design of this research is a narrative literature review, which is a method that aims to identify and synthesize the results of previous research related to the topic descriptively and thematically. This approach provides a broad and in-depth picture of the level of teacher readiness and the strategies used in integrating digital pedagogy in various educational contexts.

Data Collection Procedure

Literature searches are conducted through trusted academic databases such as Google Scholar, Scopus, and national journal portals, with a focus on publications in the last five years (2020–2025).

Search keywords include "digital teacher readiness", "digital pedagogy", "21st century learning strategies", and "digital education transformation". Literature selection is based on the relevance of the content to the research topic and the quality of the methodology adequately, without using systematic protocols such as in systematic literature review.

Data Analysis

Data obtained from the selected literature were analyzed descriptively and thematically. Descriptive analysis is used to identify common characteristics of the study, such as the type of study, location, and population being studied. Furthermore, thematic analysis was carried out to group and synthesize key findings related to aspects of teacher readiness (technical, pedagogical, and institutional support) and effective digital pedagogy implementation strategies. The synthesis of these results is used to identify research gaps and formulate recommendations for teacher capacity development in the future.

Advantages of the Method

This narrative literature review method allows research to provide a comprehensive picture based on available empirical evidence, while avoiding the time and resource limitations typically required in primary data collection. With this approach, research can make a strong theoretical contribution as well as practical recommendations that are relevant to education stakeholders.

RESULTS AND DISCUSSION

Based on the results of the literature review that has been conducted, it was found that teachers' readiness in implementing digital pedagogy in 21st century education involves several main aspects, namely technical competence, pedagogical adaptability, and institutional support (Mishra, P., & Koehler 2006). Recent studies show that most teachers already have a basic understanding of digital technology, but their level of readiness to effectively integrate technology in learning still varies (Hawinda Widya Fatma, M. Nur Fahmi, Darmawan, 2025).

Technical Competence

Most of the literature affirms the importance of teachers' technical skills as the main foundation in the use of learning technologies. However, limited access to training and technology facilities is a major obstacle that is often found, especially in remote areas (P. Saltifa, O. Hidayah, 2025). This is in line with national survey data which shows that only about 45% of teachers feel technically ready (L. Digital et al., 2025) (Redecker, n.d.).

Technical competence is a fundamental prerequisite that allows teachers to access, operate, and utilize digital devices in the learning process (Yuhanna, F., & Nugraha, 2022). In this context, the literature emphasizes that mastery of learning hardware and software must be accompanied by the ability to choose and adapt technologies that are relevant to learning objectives (Digital, A., Sari, L., & Prasetyo, n.d.).

However, as revealed by Saltifa and Hidayah (2025), this competence is still uneven nationally. Geographical and economic inequalities give rise to disparities in access to training, internet networks, and technological facilities. A national survey cited in Digital et al. (2025) shows that only 45% of teachers declare themselves technically ready, with the predominance of readiness being in urban areas. This reflects that technical competence is not solely the result of individual teacher motivation, but is also significantly influenced by the structure of opportunities available in the educational ecosystem (Hidayah, O., & Saltifa, 2025).

Furthermore, the TPACK (Technological Pedagogical Content Knowledge) approach as proposed by Mishra and Koehler (2006), shows that technical competence does not stand alone, but must be integrated with pedagogic and content aspects. In this context, teachers are not only required to be able to use technology, but also must understand how it changes the dynamics of teaching and learning (OECD, 2020).

A study from Saltifa and Hidayah (2025) states that limited access to training and technological infrastructure is still a major challenge, especially in areas with limited connectivity.

However, more than that, there are additional technical dimensions that are increasingly urgent for teachers to master, namely:

a. Cybersecurity and Data Privacy

In digital learning, teachers not only play the role of content facilitators, but also as managers of student data. Current technical competencies demand an understanding of basic cybersecurity such as recognizing malicious links, managing secure passwords, and protecting students' personal data(UNESCO n.a.). This is important in preventing information leakage and maintaining the integrity of online learning activities.

According to UNESCO (2022), low digital security literacy among educators can increase the risk of cyberattacks on educational institutions, especially when the use of third-party applications is not systematically controlled.

b. LMS Platform Management

In addition to being able to use video conferencing applications or presentation devices, teachers are also required to manage digital learning platforms such as Moodle, Google Classroom, Edmodo, or local platforms such as SIPLah. Technical competencies include the ability to compile modules, provide automated assessments, track student activities, and perform *Feedback* digital systematically(Hobbs, 2011).

c. Technical Troubleshooting Ability

Another important aspect is the teacher's ability to overcome minor technical obstacles independently, such as setting up an audio-video connection, managing corrupt files, fixing the appearance of presentation screens, or overcoming errors in online assignment synchronization(Kimmons, R., & Hall, 2018). This capability provides greater confidence in managing digital classrooms without full reliance on the assistance of technicians(Koehler, M. J., Mishra, P., Kereluik, K., Shin, T. S., & Graham n. d.).

d. Multi-Platform Integration

Teachers are also expected to have the ability to integrate various digital media such as YouTube, Canva, Kahoot, Quizizz, or Padlet into one structured learning ecosystem. This cross-platform integration creates richer, engaging, and more accommodating learning styles(Borko, 2004).

e. Digital Visual and Audio Literacy

In the content era, teachers are also required to be able to compile material in multimedia formats such as learning videos, infographics, or podcasts. This requires skills in editing simple videos, adjusting sound quality, and crafting visual narratives that are informative and communicative(Zhao, Y., & Frank, 2003).

Pedagogical Adaptability

In addition to operational technical skills, the pedagogical adaptability aspect is a strategic dimension that determines the success of technology integration in the learning process(Admiraal, W., Schenke, W., De Jong, L., Emmelot, Y., & Sligte, 2019). This adaptability not only reflects the extent to which teachers are able to utilize technology, but also how they adapt teaching methods, approaches, and styles to remain relevant, contextual, and effective in responding to the needs of students in the digital age(Digital et al. 2025)(Ertmer, P. A., & Ottenbreit-Leftwich, 2010).

Type **TPACK (Technological Pedagogical Content Knowledge)** developed by Mishra and Koehler (2006), provides a comprehensive theoretical framework for understanding the integration of technology in pedagogical practice. In this model, teachers' readiness is not enough to only understand content and technology, but also to be able to bridge the three content, pedagogy, and technology simultaneously. This requires teachers to constantly evaluate how a technology can be used not only to deliver material, but also to create meaningful learning experiences and facilitate higher-order thinking(Fullan, 2013).

Meanwhile, the DigCompEdu framework developed by the European Commission (Redecker, 2017) expands the scope of teacher adaptability evaluation by including the dimensions of teacher-student interaction, digital assessment, and management of the digital learning environment. This model emphasizes the importance of active student involvement in the technology-based learning process and the teacher's ability to be a facilitator of learning that is reflective and oriented to the needs of learners(Hennessy, S., Ruthven, K., & Brindley, 2005).

However, the current literature, including that reviewed by Digital et al. (2025), shows that although these models are widely adopted as conceptual frameworks, there are still gaps in their implementation, especially in the context of Indonesian education. These limitations include the low availability of technology-based pedagogical training tailored to local conditions, the lack of empirical studies exploring innovative practices in schools, and the lack of support for the exploration of digital-based teaching methods based on the culture and character of Indonesian students (Lim, C. P., & Khine, 2006).

This condition indicates the importance of developing adaptive pedagogical strategies, namely strategies that are able to adapt learning to technological changes, diverse student needs, and contextual challenges such as limited infrastructure or socioeconomic backgrounds of students. Teachers need to be empowered not only in the technical aspect, but also in building methodological flexibility through collaboration, reflective learning, and locality-based content development (Mueller, J., Wood, E., Willoughby, T., Ross, C., & Specht, 2008).

For example, in the context of schools with limited internet networks, adaptive pedagogical strategies can be realized through the use of media-based learning *Offline Digital* (such as interactive content on USB or CD), or the development of digital thinking-based print modules. Meanwhile, in schools that have adequate access to technology, approaches such as flipped classrooms, gamification, and project-based e-learning can be options that increase student engagement (Gudmundsdottir, G. B., & Hathaway, 2020).

Therefore, the development of innovative technology-based learning strategies is a necessity that cannot be postponed. The strategy must be *evidence-based*, contextual with local conditions, and able to accommodate a multimethodological approach oriented towards 21st century competencies such as critical thinking, collaboration, creativity, and digital literacy.

Institutional Support

Support from educational institutions and government policies also greatly affects the successful implementation of digital pedagogy (Sumarni, N., & Syamsudin, 2021). Many studies underscore the need for ongoing training, infrastructure provision, and policies that support comprehensive digital transformation (Hawinda Widya Fatma, M. Nur Fahmi, Darmawan, 2025). The inequality of facilities between urban and rural areas is still a significant challenge.

The success of the implementation of digital pedagogy depends not only on the individual capacity of teachers, but also on the systemic support of educational institutions and the public policies that govern them. Institutional support covers all aspects inherent in school management, educational organizations, and the government as the main policy makers in the digital transformation of education (Schmid, M., Brianza, E., & Petko, 2021).

1. Continuous Professional Development (CPD)

Sustainable teacher training is one of the main elements in building teachers' readiness to face technological changes. The study of Hawinda Widya Fatma, M. Nur Fahmi, and Darmawan (2025) emphasized that training that is only one-time or oriented towards understanding devices alone has proven to be ineffective enough. Training should involve reflective learning, assistance in implementation, and ongoing evaluation of its impact on the teaching and learning process (Instefjord, E. J., & Munthe, 2017).

In addition, training models that are contextual, local needs-based, and integrate frameworks such as TPACK and DigCompEdu will increase their relevance and impact. This is in line with the OECD's (2020) view that teacher professional development in the digital era must be oriented towards increasing pedagogical capacity and digital leadership, not just technical mastery (Tondeur, J., van Braak, J., Ertmer, P. A., & Ottenbreit-Leftwich, 2017).

2. Provision of Infrastructure and Equitable Access to Technology

The availability of infrastructure such as stable internet connections, hardware (computers, projectors, LCDs), and technical support are important supporting factors in the implementation of digital pedagogy. However, the reality on the ground shows that the inequality of facilities between urban and rural areas is still very striking. In many remote areas, teachers have to deal with limited signals, outdated devices, and even lack of stable access to electricity (Al-Awidi, H. M., & Aldhafeeri, 2017).

UNESCO (2022) emphasizes that this digital divide not only risks lowering the quality of education, but also widening social inequalities between regions. Therefore, the digital transformation strategy

in education must include a fair distribution of infrastructure and in favor of 3T (frontier, outermost, disadvantaged) areas.

3. Inclusive and Measurable Digital Education Policy Reform

Government policies in this context play a role as a director and regulator of resources, as well as as a link between field needs and national vision. Regulation of the Minister of Education and Culture No. 37 of 2022 (Culture n.d.), for example, has regulated the importance of continuous digital training as part of the development of the teacher profession. However, the implementation of this policy is still sporadic and has not been standardized nationally.

The Digital Literature et al. (2025) also highlights the importance of integrating technology policies with national curricula, teacher performance assessments, and incentive systems. Without this, digital pedagogy will run as an individual initiative or a temporary project that is not institutionalized in the national education system (Voogt, J., Knezek, G., Cox, M., Knezek, D., & ten Brummelhuis, 2013).

4. The Role of Educational Institutions as Agents of Digital Change

Schools and educational institutions have a strategic role as the main drivers of digital transformation at the grassroots level. School principals, supervisors, and internal curriculum development teams play an important role in shaping digital culture in the work environment. Strengthening school digital management, forming educational technology transformation teams, and developing digital-based learning communities are concrete examples of institutional support strategies that can strengthen the position of teachers in facing the challenges of digital pedagogy (Voogt, J., Knezek, G., Cox, M., Knezek, D., & ten Brummelhuis, 2013).

CONCLUSION

This study presents a comprehensive analysis of teacher readiness and digital pedagogy implementation strategies in facing the challenges of 21st century education. Based on the results of the literature review, it was found that teachers' readiness is not only determined by technical skills alone, but also greatly influenced by pedagogical adaptability and systemic institutional support. The TPACK and DigCompEdu models are important frameworks in measuring these readiness dimensions. The findings show that most teachers in Indonesia already have a basic understanding of digital technology, but there is still a gap in the ability to integrate technology effectively and contextually in the learning process. This is exacerbated by inequalities in access to training, infrastructure, and supporting policies, especially in remote areas.

This research contributes novelty by integrating psychopedagogical and technological perspectives, as well as proposing implementation strategies that are adaptive to the local context. The strategy includes ongoing training based on the TPACK and DigCompEdu frameworks, the provision of equitable digital infrastructure, and education policy reforms that drive inclusive digital transformation. The practical implications of this research are of great importance to education stakeholders, including policymakers, educational institutions, and teacher training institutions. It is hoped that the results of this study can be a reference in designing a sustainable and comprehensive teacher competency improvement program, in order to accelerate the realization of an effective, fair, and globally competitive digital education ecosystem.

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